Appl. No.: 10/707,634
Amdt. Dated: 3/12/2006
Reply to Office action of: 01/10/2006

AMENDMENTS TO THE DRAWINGS:

No amendments to the drawings are presented herewith.

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REMARKS/ARGUMENTS

There are no amendments to the specification presented herewith.

There are no amendments to the figures presented herewith.

Claims 1 and 3 – 11 remain in this application. Claim 2 has canceled. Claims 1 and 3 – 11 have been amended to correct minor editorial errors and more clearly define the claimed invention. Support for the amendments to the claims may be found, for example, in the original claims, and the Figures.

Claims 1 – 10 were rejected under 35 U.S.C. 102(b) as being anticipated by Tsuji (US Patent 6,158,232). Specifically, the Examiner states:

> With respect to claim 1 Tsuji teaches a printed circuit board (Fig. 1b) with insulated metal substrate with integrated cooling system, of the type comprising a metal substrate (Fig. 1b, element 5), at least one electrically insulating layer (Fig. 1b, element 1) adhered to said metal substrate and several electro-conducting tracks (column 3, line 14) capable of interconnecting electronic power components (Fig. 1b, element 2), adhered to said electrically insulating layer, characterizedinthatsaidmetal substrate incorporates several heat transporting channels (Fig. 1b, element 7), which comprise several conduits for a heat-carrying fluid (Fig. 1b, element 6), conduits which extend to the outside (Fig. 1a, element 4) of the metal substrate up to a heat transfer area to an external medium.
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> With respect to claim 2 and with all the limitations of claim 1, Tsuji teaches that said conduits are conduits for said heat-carrying fluid in close contact with the walls of several cavities (Fig. 1a, element 7) formed in the material of the metal substrate in a direction that is substantially parallel to said electrically insulating layer, said conduits protruding at least on one edge (Fig. 1a, element 4) of the metal substrate and extending on one portion until reaching said heat transfer area.
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> With respect to claim 3 and with all the limitations of claim 2, Tsuji teaches that said heat-carrying fluid conduits are heat pipes that are closed on both ends (Fig. 1a, element 4) and partially full of heat-carrying fluid, with an evaporation region (Fig. 1a, element 5, Note id the component (2) heats up sufficiently it will cause the water

inside the metal substrate (5) to evaporate) inside of the metal substrate and an external condensation region (Fig. 1a, element 4) extending with an inclination a distance outside of the metal substrate and which is in contact with the circulating air.

With respect to claim 4 and all the limitations of claim 2, Tsuji teaches that the said cavities (Fig. 1a, element 7) are through cavities.

With respect to claim 5 and with all the limitations fo claim 1, Tsuji teaches that that said conduits comprise several cavities placed in a direction that is substantially parallel to said electrically insulating layer, at least one of the ends of each one of said cavities opening into an opening located on at least one edge of the metal substrate, whose opening is coupled with a span of a pipe (Fig. 1a, element 4) for said heat-carrying fluid extending up to said heat transfer area.

With respect to claim 6 and with all the limitations of claim 5, Tsuji teaches that that each one of the cavities has a blind end (Fig. 1a, right end) and has only one opening on one of the edge of the metal substrate in which said span of pipe is coupled (Fig. 1a, element 4) which is provided with a blind distal end, the cavity and pipe assembly constituting a heat pipe in which the cavity performs the functions of an evaporation region inside of the substrate and the span of pipe performs the functions of a condensation region in contact with the circulating air.

With respect to claim 7 and with all the limitations of claim 6, Tsuji teaches that the opening have a countersink opening (Fig. 1b, element 7) for receiving the ends of the respective spans of pipe (Fig. 1a, element 4).

With respect to claim 8 and with all the limitations of claim 2, Tsuji teaches that said cavities have a circular cross section (Fig. 1b).

With respect to claim 9 and with all the limitations of claim 2, Tsuji teaches that said cavities (Fig. 4b) have a polygonal cross section.

With respect to claim 10 and with all the limitations of claim 4, Tsuji teaches that said cavities are parallel (Fig. 1b) to each other and have a longitudinal opening along its entire extension opening onto a side of the metal substrate that is opposite the side thereof on which said electrically insulating layer and electro-conducting tracks are fixed,

such that the metal substrate has a cross section shape that is suitable for easily being obtained by extrusion.

Applicants respectfully traverse these rejections. The key to Applicants' invention is a circuit board integrated cooling system utilizing internal cavities in a metal substrate upon which the circuit board is adhered to and in close proximity to heat-producing components mounted on said circuit board. The internal cavities being connected to external closed pipe sections which act as a condensation chamber transferring heat to the atmosphere and utilizing gravity to move cooled liquid back into the metal substrate cavities. Furthermore, these cavities can be channels within the metal substrate itself or separate pipes mounted within said channels. The need for extensive external piping, external pumps, or pumped heat-carrying fluid is thereby eliminated.

A fair reading of the Tsuji (US Patent 6,158,232) reference discloses a liquid cooling apparatus that has as critical elements a heat exchange unit, a pump for circulating liquid refrigerant, a tank for storing liquid refrigerant, a metal substrate with channels having a zigzag pattern (Figs. 5c and 6c) connected by pipe arrangement (Figs 1a, 3a, and 4a; item 4) to connect all of the zigzag channels as well as to connect all of the external to the circuit board metal substrate required components. It is critical to this reference that there be a forced liquid refrigerant system to provide sufficient cooling capacity (Fig. 2 and Col. 3, lines 35 – 42). The Tsuji reference does not disclose how to eliminate the critical elements comprising a forced liquid refrigerant, an external liquid refrigerant tank, a circulating pump, or the special zigzag channel patterns. Furthermore, contrary to the Examiner's statement item (4) is not equivalent to Applicants" claimed condensation chamber. In fact item (4) is simply a connector to allow the pumped liquid refrigerant to flow from one channel to the next and eventually back to the pump under force. There will be substantially no condensation of the refrigerant taking place under such conditions, and certainly not enough, if any, to eliminate the need for the separately plumbed external condensation tank taught by this reference as being critical. This fact is further confirmed by the teaching that special zigzag channels or special channels having configurations such that "...the liquid refrigerant 6 flowing through the liquid-passage hole 42 perpendicularly collides with the inside wall of the reservoirs 42a to 42c, where the heating units 2-1 to 2-3 are located..." (Col. 4, lines 54 – 58). This reference also teaches that the metal substrate must always have two channel holes located on its edges,

one for input of the pumped refrigerant, and one for egress of said refrigerant (Figs. 1a, 3a, 4a, 5a, 6a, and Col. 3, lines 18 – 24).

Clearly, when viewed in this light the Tsuji reference does not disclose, teach, or fairly suggest the circuit board cooling system of the claimed invention having no requirement for external pumps, condensation chambers, refrigerant tanks, or both ingress and egress holes from the channel containing metal substrate.

Claim 11 was rejected under 35 U.S.C. 103(a) as being unpatentable over Tsuji in view of Schlaiss (US Patent 5,929,518). Specifically, the Examiner states:

> With respect to claim 11, Tsuji teaches all of the limitations including a metal substrate with cavities. Tsuji does not teach that the substrate comprises two layers that are joined together and that the cavities are formed by the juxtaposition of tow semi-cavities found respectively on each one of the layers. Schlaiss teaches a two-layer substrate (Fig. 1, elements 12 and 13) that are joined together and that the cavities are formed by the juxtaposition of two semi-cavities found respectively on each one of the layers. It would have been obvious tone of ordinary skill in the art at the time of the inventions to form the substrate, taught by Tsuji, by the method taught by Schlaiss, because doing so allows the cavity to be cleaned and or fixed with ease by simply opening up the substrate when needed.

Applicants respectfully traverse the rejection. The key to Applicants' invention, as mentioned hereinabove, is a circuit board integrated cooling system utilizing internal cavities in a metal substrate upon which the circuit board is adhered to and in close proximity to heat-producing components mounted on said circuit board. The internal cavities being connected to external closed pipe sections which act as a condensation chamber transferring heat to the atmosphere and utilizing gravity to move cooled liquid back into the metal substrate cavities. Furthermore, these cavities can be channels within the metal substrate itself or separate pipes mounted within said channels. The need for extensive external piping, external pumps, or pumped heat-carrying fluid is thereby eliminated.

A fair reading of the Tsuji (US Patent 6,158,232) reference, as discussed above, discloses a liquid cooling apparatus that has as critical elements a heat exchange unit, a pump for circulating liquid refrigerant, a tank for storing liquid refrigerant, a metal

substrate with channels having a zigzag pattern (Figs. 5c and 6c) connected by pipe arrangement (Figs 1a, 3a, and 4a; item 4) to connect all of the zigzag channels as well as to connect all of the external to the circuit board metal substrate required components. It is critical to this reference that there be a forced liquid refrigerant system to provide sufficient cooling capacity (Fig. 2 and Col. 3, lines 35 – 42). The Tsuji reference does not disclose how to eliminate the critical elements comprising a forced liquid refrigerant, an external liquid refrigerant tank, a circulating pump, or the special zigzag channel patterns. Furthermore, contrary to the Examiner's statement item (4) is not equivalent to Applicants" claimed condensation chamber. In fact item (4) is simply a connector to allow the pumped liquid refrigerant to flow from one channel to the next and eventually back to the pump under force. There will be substantially no condensation of the refrigerant taking place under such conditions, and certainly not enough, if any, to eliminate the need for the separately plumbed external condensation tank taught by this reference as being critical. This fact is further confirmed by the teaching that special zigzag channels or special channels having configurations such that "...the liquid refrigerant 6 flowing through the liquid-passage hole 42 perpendicularly collides with the inside wall of the reservoirs 42a to 42c, where the heating units 2-1 to 2-3 are located..." (Col. 4, lines 54 – 58). This reference also teaches that the metal substrate must always have two channel holes located on its edges, one for input of the pumped refrigerant, and one for egress of said refrigerant (Figs. 1a, 3a, 4a, 5a, 6a, and Col. 3, lines 18 – 24).

A fair reading of the Schlaiss (US Patent 5,929,518) reference discloses a circuit board having channels in the substrate that in one embodiment are created by the juxtaposition of two or more layers of said substrate material. Further, the reference teaches the circuit board is cooled using a forced coolant system plumbed from external to the circuit board (Fig. 1, item 38; Fig. 2, item 57; Col. 2, line 65 – Col. 3, line 15; and Col. 3, line 66 – Col. 4, line 7) similar in nature to forced system of the Tsuji reference cited above. Thus, while the Schlaiss reference does teach the use of juxtaposition of layers of substrate to form complete channels within said substrate it does not teach how to eliminate the critical elements of its teaching or that of the Tsuji reference to reach the invention claimed in this application. Thus, no combination of the Tsuji reference and the Schlaiss reference discloses, teaches, or fairly suggests Applicants" claimed invention.

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Clearly, when viewed in this light the Tsuji reference in combination with the Schlaiss reference does not disclose, teach, or fairly suggest the circuit board cooling system of the claimed invention having no requirement for external pumps, condensation chambers, refrigeranttanks, orbothingress and egress holes from the channel containing metalsubstrate.

In view of the remarks herein, and the amendments hereto, it is submitted that this application is in condition for allowance, and such action and issuance of a timely Notice of Allowance is respectfully solicited.

Respectfully submitted,

Bruce E. Harang

Bruce E. Harang
Registration No. 29,720
Tel.: (360) 903-4693